Longitudinal Assessment of Neurocognitive Function after Cardio pulmonary Bypass

This dissertation is submitted to

The TamilNadu Dr.MGR Medical University

Chennai- 32.

in partial fulfillment of the requirement for the award

of degree

M. Ch. Branch I Cardiothoracic Surgery

Madras Medical College & Research Institute

Chennai- 3.

August 2007

CERTIFICATE

This is to certify that this dissertation titled

"**Longitudinal Assessment of Neurocognitive Function after Cardio pulmonary Bypass**"

submitted by

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appearing for

M. Ch. Branch I Cardiothoracic Surgery degree

examination

in

August 2007

is a bonafide record of work done by him under my

guidance and supervision.

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ACKNOWLEDGEMENT

I convey my sincere thanks to the Dean, Madras Medical College, Chennai for permitting to conduct this study.

I am deeply indebted to my Professor and Head of department, **Prof.K.HARSHAVARDHAN** for his sincere guidance and help.

I am also thankful to **Prof.L.VENGADACHALAPATHY** for his help, direction and encouragement throughout the study. I am also grateful and indebted to Additional Professors **Prof.S.MANOHARAN, Prof.S.VISWA KUMAR** and **Prof.T.A.VIJAYAN** for their help and guidance at every part of the study

I convey my sincere thanks to all my Assistant professors for their valuable guidance and encouragement.

I also thank the Professor of Psychiatry and his department for providing me technical guidance and the test batteries.

Above all, I thank my patients for their co-operation rendered in conducting this study.

Longitudinal Assessment of Neurocognitive Function after Cardio pulmonary Bypass

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INTRODUCTION

Introduction

In 1954, Lillehei first reported the effective use of Extracorporeal circulation in the repair of CHD using cross circulation with the patient's parent functioning as the oxygenator. Gibbon first described and used a mechanical extracorporeal oxygenator, which he termed the Heart-Lung machine. On May 6, 1953, Gibbon performed the first successful Open heart surgery using a Heart-Lung machine while repairing an Atrial Septal defect. Increasingly complex repairs subsequently became possible with the refinement of Cardiopulmonary bypass (CPB) techniques and the use of hypothermic circulatory arrest that Barratt-Boyes et al (1971) and Castaneda et al (1974) popularized. Further refinements in CPB hardware and techniques, perfusion methods, myocardial and Brain protection over the past 2 decades contributed to improved outcomes of surgical treatment of CHD.

The use of CPB is associated with significant cerebral morbidity. The two main clinical manifestations of Brain injury after CPB are Stroke and Cognitive decline. Cognitive decline has increasingly been recognized as a complication after cardiac surgery. Although important advances in techniques for perioperative anesthesia, surgery, and the protection of organs have resulted in substantial reductions in age-adjusted and risk-adjusted mortality, the incidence of cognitive decline has changed little over the past years. The quality of life of patients undergoing cardiac surgical procedures has recently received much attention, especially with respect to the effect of such procedures on cognitive and neuropsychologic outcomes. Elderly patients with multiple health problems, who are at higher risk than other groups of patients for Neurologic and Neurocognitive problems, are now able to undergo surgical procedures relatively late in life without serious concern about loss of life. However, they are at substantially increased risk

for Central Nervous System dysfunction and, in particular, Cognitive decline after surgery. The clinical and financial implications of these problems can be profound, since prolonged hospitalization and an increased use of resources are associated with major and even minor Neurobehavioral declines.

AIM

Aim

This prospective study has been conducted to evaluate various factors associated with Cognitive dysfunction and is aimed at improving the surgical outcome in our patients. The aim of this study is

To perform pre operative Cognitive evaluation and to study the incidence of Cognitive decline after cardiac surgery.

1. To assess the manifestations of Neurocognitive decline after Cardio pulmonary bypass
2. Comparison between results concerning Cognitive decline in our patients and previous clinical reports and identification of incremental risk factors.
3. To discuss various modalities in improving the surgical outcome.

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MATERIALS AND METHODS

Materials and methods

Subjects

This study was conducted at The Department of Cardiothoracic Surgery, Madras Medical College and Government General Hospital, Chennai from November 2004 to January 2007. Institutional ethical clearance was obtained for the study. 95 patients who underwent elective open-heart surgery in different units were taken up for the study. Patients who had emergency surgery, who underwent procedures in Deep Hypothermia or Circulatory arrest, who had a History of Stroke, Seizures or previous Psychiatric pathology, Carotid artery disease or Cardiac tumors were not included in the study. Also patients who had less than eighth standard of education

or who could not read were excluded. Evaluation was done pre operatively; 7 days post operatively and during the 6^{th} month of follow up.

Procedures

All patients were subjected to a standardized anesthetic and bypass management. Anesthesia was induced with Midazolam hydrochloride, 50 to 100 µg/kg, and Fentanyl citrate, 5 to 10 µg/$kg^{-1/}$ min^{-1}. Vercuronium bromide was given as needed to maintain complete neuromuscular blockade. The procedures were performed under moderate hypothermia (32°C - 34°C), using a nonpulsatile pump flow of 2.4 L/m^2 per minute at maximal pump force, a membrane oxygenator (Sorin Monolyth pro), and 40-µm Membrane filters. Anticoagulation was adjusted at an Activated Clotting Time of

longer than 400 seconds. Mean arterial pressure was maintained at 60 mm Hg or higher

Neuropsychological assessment

The following instruments assessed cognitive functioning:

I. ***Montgomery – Asberg Depression rating scale*** for assessment of Depression. This rating is based on a clinical interview, which moves from broad questions about symptoms to more detailed ones that permit rating of severity. Score ranges from 0 – 60 [0-6 normal / recovered, 7-19 mild depression, 20-34 moderate depression, 35-60 severe depression].

II. ***Clinical anxiety scale*** to assess the present state of anxiety by eliciting information of how the patient felt. This has been derived from Hamilton Anxiety scale and score ranges from 0 – 24 [0-4 normal / recovered, 5-10 mild anxiety, 11-16 moderate anxiety, 17-24 severe anxiety].

Mini mental state examination is a brief, quantitative measure of Cognitive status in adults. The test has a range of 30 points, from normal (30) to severe impairment (0). Cut off score of 23 has been suggested for presence of Cognitive impairment.

III. ***Trail making test, A and B*** from the Halstead-Reitan

Neuropsychological test battery requires subjects to connect, as quickly as possible, a series of numbers (part A, 1-2-3 etc) and letters and numbers in alternating sequence (part B, 1-A-2-B etc). The tests are good predictors of general mental ability, visual and nonverbal intelligence.

IV. ***PASAT (Paced Auditory Serial Addition Test)***, to add the number just presented to the one immediately preceding it and say that sum aloud. The integrity of the attentional processes and rate of information processing are assessed in this test.

Definitions of Decline

To determine the presence and extent of cognitive change, we used the following criteria:

I. **Standard deviation (SD).** Decline of more than 1 SD from baseline test scores.

II. **20% change.** Decline in test scores by at least 20% from baseline test scores.

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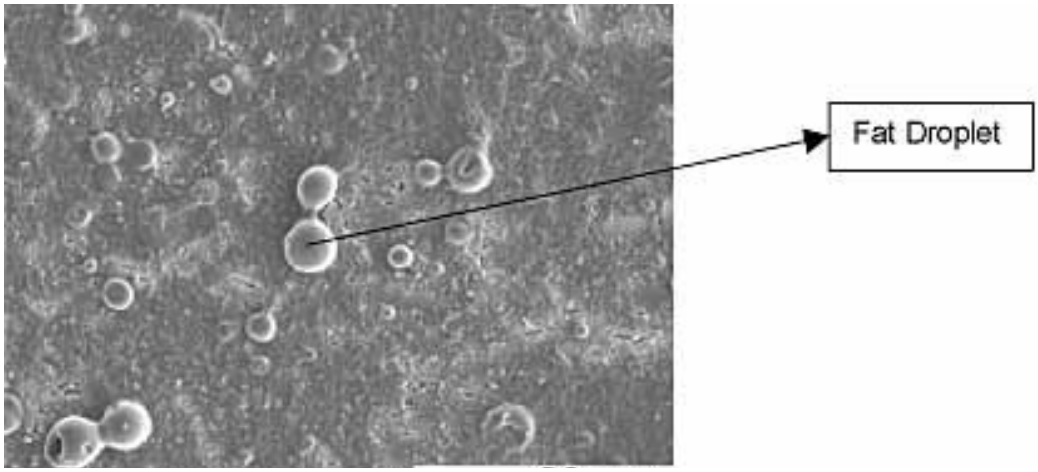
REVIEW OF LITERATURE

REVIEW OF LITERATURE

The impact of Cardiac surgery on the Brain is multifactorial. Early postmortem studies emphasized the role of anoxia in causing injury to arterial border zone regions, in particular the hippocampi.[1-3] More recently, the most popular explanation for Cognitive changes is Microemboli delivered to the brain during surgery. These can be either air or particulate (atheromatous matter, fat, platelet aggregates, etc).

Electron micrograph of blood during CPB showing fat droplets.



The measurement of the occurrence of Microemboli during cardiac surgery can be achieved with the use of Transcranial Doppler where the

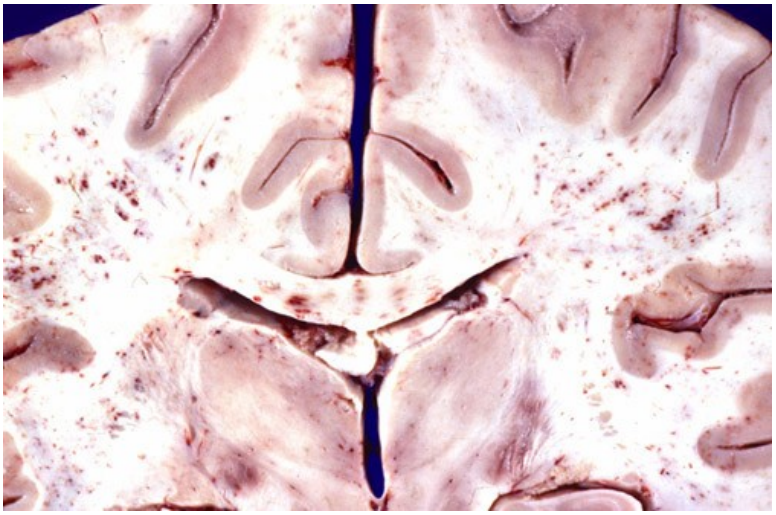
Microemboli produce a characteristic High frequency disturbance "HITS" (High intensity transcranial signals). Transcranial Doppler is now commonly used in cardiac surgery research but researchers are unable to distinguish between gaseous and particulate Microemboli.

Trans cranial Doppler showing "HITS"

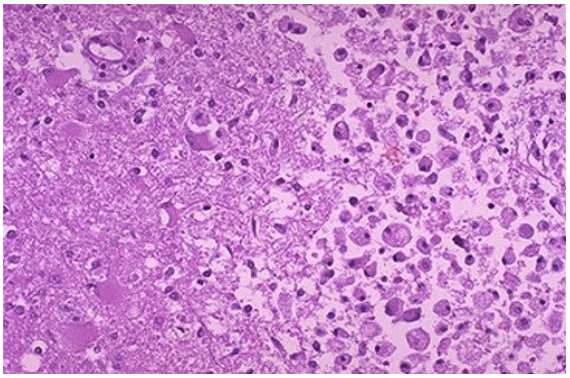
Histopathologic and MRI studies have demonstrated the vulnerability of specific brain regions to intraoperative injury in cardiac surgery employing Cardiopulmonary Bypass (CPB). The most common sites of MRI defined infarction are within the deep sub

cortical white matter, basal ganglia, caudate nucleus, and corona radiata.[4-10]

Cut section of brain showing peticheal haemorrhages after CPB



Cut section of brain showing peticheal haemorrhages after CPB



Histology showing embolus inside blood vessel with surrounding inflammatory cells

Neuropathological studies have identified the occurrence of what have been termed small capillary and arteriolar dilatations (SCADs) in the brains of both patients who have died during cardiac

surgery and dogs that underwent experimental cardiopulmonary bypass, but not in those who have not been on extracorporeal circulation.[9] It has been assumed that there is a relation between the microemboli and SCADS, though the SCADS appear to resolve over time.

Patient characteristics such as age and disease (such as the extent of atheroma), anaesthetic and bypass intervention equipments have an impact on Neuropsychological outcome, much work has focused on the impact of different techniques and equipment on Neuropsychological performance. The most direct attempt to deal with the potential deleterious effects of Coronary artery bypass grafting has been to examine the impact of modifying bypass equipment.

The role of Arterial line filters in reducing the impact of Microemboli during cardiac surgery has been explored in a number of studies. Padayachee and colleagues[20] and Pugsley and colleagues[21] found the introduction of an Arterial line filter significantly reduced the number of emboli detected at the Middle cerebral artery during CABG. One study found significantly reduced deficits in the filter group (8% v 27%) eight weeks after surgery.[21]

Comparisons between Bubble and Membrane oxygenators have shown significant differences in the occurrence of emboli as assessed using Retinal fluorescein angiography and some suggestion of reduced Neuropsychological deficits in the Membrane oxygenator group.[22]

A comparison between pulsatile and non-pulsatile flow failed to find any advantages for either procedure.[23] Whether these two modes of perfusion are able to lead to perceptible differences in the brain is questionable, as Doppler recordings in the Middle cerebral artery tend to show non-pulsatility of flow even when pulsatile bypass is used.

The use of Hypothermic perfusion during Cardiopulmonary bypass has been based on the protective effects of low temperature in limiting the effects of cerebral ischemia. A number of studies have examined whether Hypothermic bypass reduces the impact of cardiac surgery on Neuropsychological tests; they have not presented a clear picture. Notably one large study found a

significantly higher incidence of neurological problems in Normothermia, which was not paralleled in a subset of patients who underwent Neuropsychological testing.[24] The issue of temperature during bypass is more complex than is immediately apparent. For example, what is termed Normothermic bypass can involve a range of different procedures such as deliberately re-warming to maintain normothermia, to letting the temperature drift during bypass. Hypothermia occurs at the time most cardiac manipulations are conducted and therefore at the time when emboli are likely to occur. In addition, Hyperthermia may occur during re-warming and it is possible that this is the time of most damage to the brain.

Two studies that examined the impact of pH management both reported advantages for the alpha stat technique.[23] Patel and colleagues[25] reported less disruption to autoregulation in the alpha stat group, offering some potential explanation for the differences found between alpha stat and pH stat regimens.

harmacological in**terventions**

The mechanisms of Ischemic Brain damage are complex leading to a range of possibilities for pharmacological intervention in CABG. Neuroprotection has been used in cases of Circulatory arrest where preservation of Cognitive function as assessed by Neuropsychological tests has been demonstrated. In CABG, however, little evidence of neuroprotection has been found. Similar findings have been reported in a study of Prostacyclin[27]. Calcium channel blockers and GM_1 gangliosides have both been applied in randomised controlled studies but only on small numbers.[18] [28]

One large study[17] used an NMDA receptor antagonist (remacemide [(+) 2-amino-N-(methyl-1,2-diphenylethil)-acetamide] hydrochloride) in a large prospective double blind randomised trial. Patients receiving Remacemide had significantly greater preservation of learning on the Neuropsychological battery compared to the placebo group. The increased capacity for learning

in the remacemide group may therefore be considered a reflection of the protection accorded to the Nervous system by this agent during bypass.

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RESULTS

Results

This study was conducted in 95 eligible patients, 47 of whom were females and 48 males. The mean age of the patients was 30.66 ±12.33 (females 28.35 ±10.18, males 33.5 ±13.95). 6 patients did not turn up for follow up at 6 months.

29 patients underwent surgical correction for Atrial septal defect,

7 patients for Ventricular septal defect,

1 patient had Ventricular septal defect with Aortic regurgitation,

1 patient had Left Atrial myxoma,

30 patients underwent surgery for Mitral valve disease

Mitral stenosis	5
Mitral regurgitation	15
Mitral Restenosis	1
Mitral stenosis with LA clot	3
Mitral stenosis with regurgitation	6

9 patients had Aortic valve disease

Bicuspid Aortic Valve	1
Aortic stenosis	1
Aortic regurgitation	4
Aortic stenosis with regurgitation	2
Rupture of Sinus of Valsalva	1

4 patients had both Aortic and Mitral valve disease.

Aortic regurgitation with Mitral regurgitation	3
Aortic regurgitation with Mitral stenosis	1

14 patients had coronary artery disease and underwent bypass grafting. Saphenous veins formed majority of conduits used with the mean number of grafts being 2.08 ± 0.49.

Various risk factors were analysed for their impact on the outcome. Patients had the following risk factors

Smoking	22
Alcohol	14
Hypertension	14
Diabetes mellitus	9
Myocardial infarction	8

But the impact of the following risk factors on the Postoperative

Cognitive decline was not significant.

Pulmonary hypertension based on pre operative echocardiographic measurement was another risk factor.

mild	9
moderate	5
severe	13

Postoperative tests scores were almost similar in all the three groups.

The mean Left Ventricular end diastolic dimension was 4.06 ± 1.08cms, mean Left Ventricular end systolic dimension 3.08 ± 0.81cms and Ejection fraction 55.92 ± 9.71 %.

Patients underwent following surgeries

Atrial septal defect	Pericardial patch closure	28
	Direct closure	1
Ventricular septal defect	Patch closure	5
	Direct closure	2
Ventricular septal defect with Aortic regurgitation	Patch closure with Aortic valve replacement	1
Mitral valve disease	Mitral valve replacement	28
	Open mitral valvotomy	2
Aortic valve disease	Aortic valve replacement	8
Aortic valve and Mitral valve disease	Double valve replacement	3
	Open mitral valvotomy with Aortic valve replacement	1
Coronary artery disease	Coronary artery bypass grafting	14
Left atrial myxoma	Excision	1
Rupture of Sinus of Valsalva	Excision and patch closure	1

The surgeries were performed in Hypothermia with the temperature at Cross clamp application 33.30 ± 0.74 ˚c, Cross clamp duration 68.96 ± 30.04 mins, extra corporal circulation time 116.52 ± 40.81 mins and post operative hospitalization period 13 ± 2.24 days.

Various postoperative adverse events that were identified are tabulated.

Bleeding	7
Sternum revision	3
Persistent AF	6
Low cardiac output	4
Myocardial infarction	2
Wound infection	14
Secondary Suturing	20
ARDS	1

In the study conducted, we have analysed the incidence of various Psychiatric manifestations by battery of tests before and after surgery. The incidence of Depression based on the ***Montgomery- Asberg Depression rating scale*** is

	Pre Operative %	Post Operative %	Follow Up %
Mild	3	19	8
Moderate	-	17	3
Severe	-	18	-

The incidence of Anxiety based on ***The Clinical Anxiety scale*** is

	Pre Operative %	Post Operative %	Follow Up %
Mild	4	9.5	6
Moderate	-	1	5

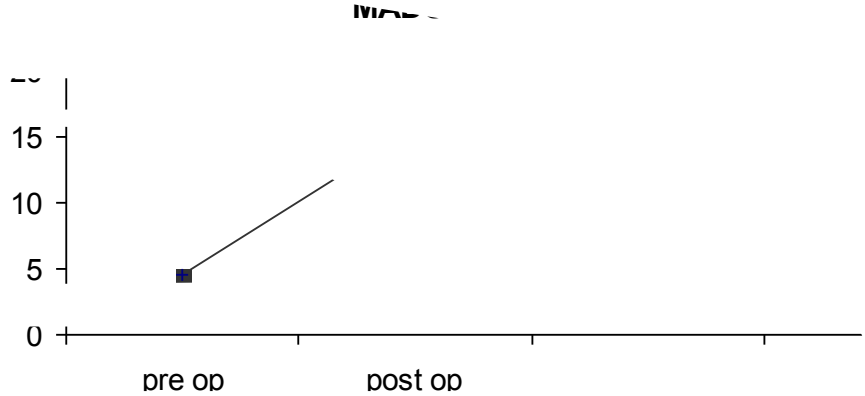
Severe	-	25	-

And the incidence of Neurocognitive dysfunction based on Cognitive assessment by a battery of tests is 46.3% in postoperative period and 13.7% at 6 months.

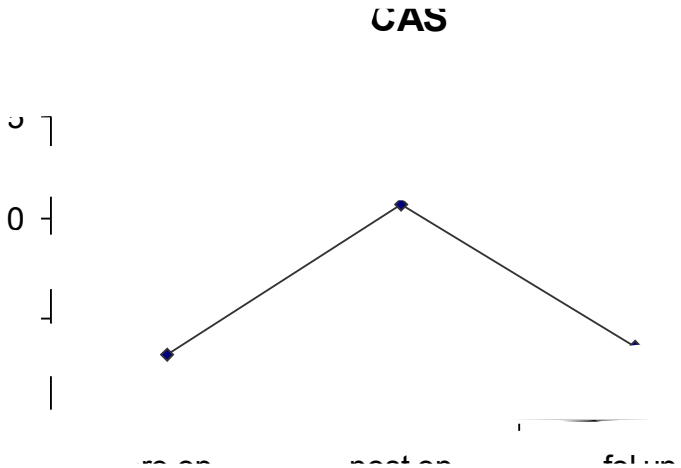
The scores of various tests conducted in the study

Test	Pre op (Mean± SD)	Post op (Mean± SD)	Follow up (Mean± SD)
MADS	4.59 ± 1.5	15.57 ± 13.76	5.44 ± 4.11
Clinical Anxiety scale	3.22 ± 1.2	10.62 ± 7.26	3.69 ± 2.64
MMSE	25.48 ± 2.26	20.20 ± 3.92	24.51 ± 2.46
TMT-A	69.95 ± 13.67	100.36 ± 24.15	78.85 ± 21.16
TMT-B	127.67 ± 30.46	170.46 ± 46.21	137.49 ± 41.68
PASAT	23.81 ± 2.61	29.11 ± 5.79	24.22 ± 3.38

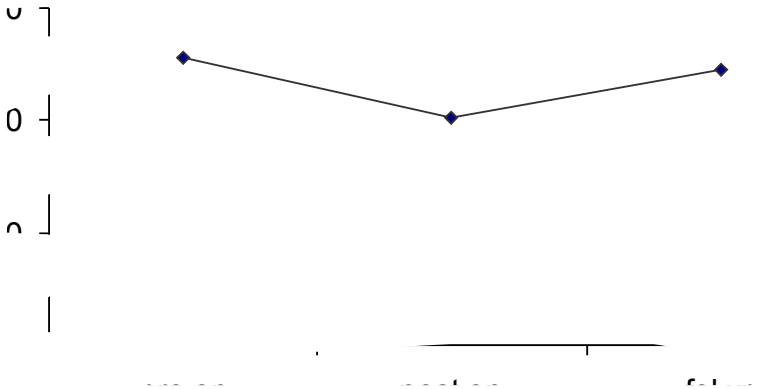
Graphs of mean test scores.



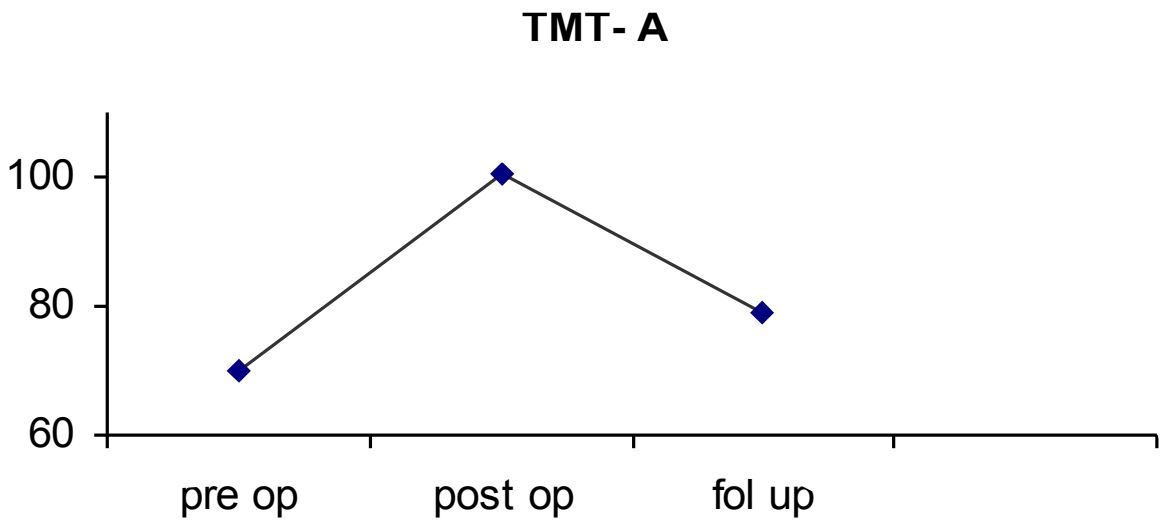
Montgomery- Asberg Depression rating scale



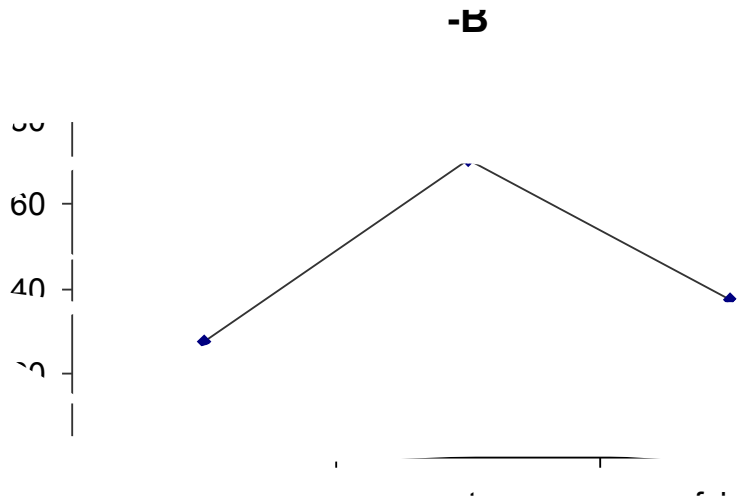
The Clinical Anxiety scale



Mini Mental State Examination



Trail making test – A



Trail making test – B

Paced Auditory Serial Addition Test

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DISCUSSION

Discussion

The incidence of Neurocognitive Dysfunction in the study is 46.3% in postoperative period and 13.7% at 6 months. This was comparable to the incidence in studies conducted by different groups.

	Postoperative	Follow up (6 months)
Diederik van Djik et al[14]	4 % – 47 %	3.4 %– 19. 4 %
Mark Newmann et al[13]	53 %	24 %
Ernest et al[11]	27 %	21 %
Present study	46.3 %	13.7 %

Lewis and Ernest had demonstrated an increase in the detection of Postoperative Cognitive decline with increase in number of tests in a battery. The incidence increased from 13.3 % to 49.4 % as the test batteries increased from 2 to 7 tasks. In the present

study we used a Battery of 3 tests to evaluate the decline

The Demographic factors in the study group was compared with two other study groups

	Age	Male sex%	Hypertension%	Diabetes%
Mark Newmann et al[13]	60.9 ± 10.6	74.7	51.2	14
Ernest et al[11]	63.7 ± 10.7	81	79	27
Carrascal et al[15]	67 ± 9.67	58.3	45.5	23.5
Present study	30.66 ± 12.33	47.4	14.7	9.5

There was a higher mean age and consequently a higher incidence of Diabetes and Hypertension in the other study groups but neither study related these risk factors to cognitive decline in post op period.

Age wise analysis revealed gradual increase in postoperative Cognitive dysfunction with age.

Age group	Postoperative	Follow up (6 months)
10 – 20	29 %	5 %
20 – 30	45 %	10.5 %
30 – 40	57 %	14 %
40 – 50	53 %	15 %
50 and above	50 %	17 %

This could also be partially attributed to Atrial septal defects forming the bulk of cases in the 10 – 20 years age group and consequently associated with shorter cross clamp and Extra corporeal circulation time.

Analysing the outcome of patients within the study group we could infer the following.

Anxiety, Depression and Neurocognitive dysfunction was higher among female patients. Valvular surgeries and Coronary artery

	ASD		MVR		AVR		CABG
	Female	Male	Female	Male	Female	Male	
X C temp	33.76±0.56	33±0.67	33±0.56	33.37±0.74	33±0.81	33.29±0.95	33.54±0.78
X C time	38.64±20.22	41.2±16.99	89.35±15.20	79.88±22.74	92.5±8.81	94.28±26.16	83.92±23.08
ECC time	70.94±27.37	82.3±29.06	145.15±17.36	134±28.5	146.25±17.01	154.43±32.57	137.31±28.77
MAD Pre	4.41±1.32	4.3±0.67	4.8±0.69	4.5±0.75	4.75±0.5	4.71±0.76	4.77±3.21
MAD PO	13.11±12.46	8.1±11.30	12.4±10.15	6.63±2.13	11.75±1.5	16.71±13.8	33.85±8.45
MAD FO	6.88±5.33	4.0±1.41	5.23±3.08	4.13±1.25	4.33±0.58	6±4.10	7±5.9
CAS Pre	3.11±1.21	2.7±1.16	3.7±1.52	2.75±0.89	3.5±0.58	3.42±0.79	2.69±1.11
CAS PO	9.36±7.77	4.4±4.14	8.9±6.48	8.88±9.96	9.75±2.06	10.71±8.44	18.07±4.54
CAS FO	4.35±3.88	2.5±0.7	3±1.08	2.87±1.13	3.33±0.58	4.5±4.32	4.42±3.17
MMS Pre	26.52±1.91	27±2.58	24.95±1.82	25.5±1.60	26±1.82	24.7±1.11	23.92±2.66
MMS PO	21.88±3.37	23.7±3.16	18.6±3.33	20.38±3.38	19.75±2.75	18.71±2.98	17.38±3.52
MMS FO	25.18±2.6	26.56±2.13	23.61±2.30	25±1.41	23.67±1.53	22.17±2.48	22.92±2.47
TMA Pre	67.23±14.46	57.1±16.31	74.45±10.98	75±10.7	71±9.31	76.14±12.36	79.15±9.75
TMA PO	94.17±18.68	77.7±30.11	111.05±23.3	114.25±25.8	99.75±9.54	101.86±17.62	112.92±16.84
TMA FO	73.53±18.5	62.33±24.54	87.39±18.92	91.38±29.45	78±3.46	79.33±9.4	92±19.24
TMB Pre	127.06±46.76	100.4±24.44	131.7±24.67	147.25±26.41	130±23.78	126±15.46	146.15±16.59
TMB PO	160.65±47.53	123.8±33.90	179.9±40.15	206.38±47.16	159±26.65	162.43±31.58	200.92±29.58
TMB FO	131.94±47.88	100.11±31.43	143.94±35.84	171.88±47.8	136.67±17.01	141.17±32.53	167.17±31.94
PAS Pre	23.88±24.5	24.5±2.68	23.3±2.05	23.5±2	23.5±1	22.71±1.8	25.46±2.99
PAS PO	32.7±8.95	25.8±5.01	29.3±8.71	28±2.78	26.25±2.06	29.51±4.93	31.54±5.88
PAS FO	24.88±3.26	24.89±2.93	24.94±2.86	24.5±2.20	26±3.61	22.83±1.41	24.33±4.08

bypass grafting had greater Cognitive decline than other

procedures. This could possibly be due to effect of Microemboli. Postoperative Cognitive decline could also possibly be due to increase in Cross clamp time and Extracorporeal circulation time. Also patients who had Neurocognitive dysfunction at immediate postoperative period had higher incidence of dysfunction at 6 months follow up.

Yolanda Carrascal et al at the Department of Cardiac Surgery, University Hospital of Valladolid, Spain studied various aspects of cognitive decline and presented their findings at the 53rd International Congress of the European Society for Cardiovascular Surgery[15]. This was compared with the present study

Comparison of present study with Carrascal et al study

	Yolanda Carrascal et al	Present study
Age	67 ± 9.67	30.66 ± 12.33
LVEF	62.42 ± 11.72	55.92 ± 9.71
Num. grafts	2.57 ± 0.96	2.08 ± 0.49
Cross-clamp time (min)	62.27 ± 22.80	68.96 ± 30.04

Extracorporeal circulation time (min)	84.87 ± 27.6	116.52 ± 40.81
Postoperative follow-up (days)	7.67 ± 5.38	13 ± 2.24
Preoperative MMS score*	29.29 ± 3.42	25.48 ± 2.26
Postoperative MMS score*	30.62 ± 3.91	24.51 ± 2.46
PASAT preoperative score	27.04 ± 11.05	23.81 ± 2.61
PASAT postoperative score	25.81 ± 11.83	29.11 ± 5.79
PASAT score follow up	27.93 ± 13.11	24.22 ± 3.38

They had reported a higher incidence of decline with older age and Valvular heart surgery. In the present study, Female sex, Valvular surgeries and Coronary artery bypass grafting had greater Cognitive decline than other procedures. Coronary artery disease and Valvular heart disease formed majority of patients in our study group and were associated with higher incidence of decline.

Newmann et al from the Neurological outcome research group

in their study of 261 patients reported old age, higher baseline Neurocognitive function and lower educational levels as Predictors of long term Cognitive decline[13] [26]. Sex, Duration of cardiopulmonary bypass, and Duration of Aortic cross clamping were not significant factors though Left Ventricular Ejection fraction had some significance indicating that patients with Cardiac dysfunction may be at increased risk of Postoperative Cognitive Decline.

Comparison of present study with Newmann et al study

	Newmann et al	Present study
Age	60.9 ± 10.6	30.66 ± 12.33
Male sex %	74.7	50.5
LVEF	51.7 ± 11.9	55.92 ± 9.71
Cross-clamp time (min)	47.8 ± 18.3	68.96 ± 30.04
Extracorporeal circulation time (min)	111.6 ± 34.5	116.52 ± 40.81
TMT - B preoperative score	142.24 ± 73.56	127.67 ± 30.46

TMT - B postoperative score	158.77 ± 81.81	170.46 ± 46.21
TMT - B score follow up	106.77 ± 64.27	137.49 ± 41.68

Though the results of both the study groups were comparable, we did have a significant decrease in Cognitive function with prolonged cross clamp duration and Extracorporeal circulation time. This could probably be due to higher numbers of valvular surgeries in our study group and consequently higher rates of Microembolic injury.

However results of different studies cannot be directly compared even when the statistical criteria for change are the same. Results need to be more cautiously examined relative to the size and composition of Neuropsychological assessment batteries.

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CONCLUSION

Conclusion

Neurocognitive Dysfunction is a frequently occurring complication. The results confirm a High Incidence of Cognitive decline. The incidence in our study was 46.3% in the immediate postoperative period and 13.7% at 6 months.

Female patients who constituted 49% of the study group had a Higher Incidence of Anxiety, Depression and Neurocognitive dysfunction.

Patients with Lower Ejection Fraction pre operatively had Higher rates of Cognitive decline. This could be due to lower

baseline Neurocognitive function in this group of patients.

Valvular heart surgeries and Coronary artery bypass grafting were also associated with Higher cognitive decline. These surgeries were associated with Prolonged Cross clamp time and Extracorporeal circulation time. Extracorporeal circulation causing microscopic air embolism and Cerebral and Systemic Inflammatory Activation may be responsible for transient disturbance of Neuronal Metabolism. Microscopic Air embolism could result in Diffuse Cerebral Hypoxemia. However we performed no transcranial Doppler measurements to visualize and confirm the emboli.

Lower baseline Neurocognitive function was also associated with Higher rates of Cognitive decline. Pre surgical counseling by Psychologists may probably help in improving the Postoperative Psychological Status.

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PROFORMA

PROFORMA

Name		Age					Sex	M / F
IP no		Age group	10 - 20	20 – 30	30 – 40	40 – 50	≥ 50	

Education	Literate (up to 8th std)	High School	Graduate	Post graduate

Risk factors:

Smoking	+		-	
Alcohol	+		-	
Hypertension	+		-	
Diabetes mellitus	+		-	
Renal insufficiency	+		-	
COPD	+		-	
Calcification of Valves	+		-	
Previous MI	+		-	
PHT	Nil	mild	moderate	severe

Diagnosis:

Congenital heart disease			Clot	Calcification	Vegetation
Mitral valve disease	stenosis	regurgitation	+ / -	+ / -	+/ -
Aortic valve disease	stenosis	regurgitation	+ / -	+ / -	+ / -
Coronary artery disease	Left main	Single vessel	Two vessel		Three vessel
NYHA Class	I	II	III		IV
Rhythm	sinus	AF	Other		

Pre Op Cardiac dimensions:

Left Ventricle Volume – Diastole	
Left Ventricle Volume – Systole	
Left Ventricle Ejection fraction	

Surgery:

Congenital heart disease					
Mitral valve surgery	Valve replacement	Valve repair			
Aortic valve surgery	Valve replacement	Valve repair			
CABG – No of grafts	LIMA / SVG	1	2	3	4

Procedure details:

Temperature at Cross clamping	
Cross clamp duration	
Extra corporal circulation duration	
Post operative period	

Adverse events:

a. Bleeding	b. Sternum revision	c. Persistent AF
d. Low cardiac output	e. Myocardial infarction	f. Stroke
g. Wound infection	h. Sec. Suturing	i. ARDS
j. Arrhythmias	k. Sacral sore	

Neuropsychological measures:

Test	Pre op	Post op	Follow up
MADS			
Clinical Anxiety scale			
MMSE			
TMT-A			
TMT-B			
PASAT			